COMPARATIVE EFFICACY OF FOUR RODENTICIDES ON THE GHANAIAN MARKET

F. Gbogbo and K. A. Adomako
Department of Animal Biology and Conservation Science, University of Ghana, Legon

ABSTRACT
Due to the enormous damage that rodents cause to agricultural produce, merchandise and human health all over the world, large sums of money is often spent on rodenticides in order to control rodent populations. A number of rodenticides exist on the Ghanaian market on which there is limited scientific data on their efficacy and use. This study investigated the efficacy of four rodenticides namely Storm (flocoumafen at 0.005% w/w), Baraki (difethialone at 0.0025% w/w), Chinaman (diphacinone at 0.005% w/w) and Zinc Phosphide on the Ghanaian market, on white laboratory rats (Rattus novigicus). The results indicated that product acceptability by the rats within 24 hours was significantly higher for Storm (20.6±1.3g) and Baraki (17.8±5.5g) as compared to Chinaman (5.4±0.3g) and Zinc Phosphide (3.2±1.7g) (ANOVA, $p < 0.05$). Consumption of Storm, Baraki and Zinc Phophide produced lethal effects with mean time of death ranging from 4.0±1, 3.8±1 to 1.0 days respectively indicating that Baraki and Storm exhibited delayed lethal effects. Although product acceptability for Zinc Phosphide was low, the amount needed to produce lethal effects in white laboratory rats was small and appeared to have been consumed over a single encounter. The study provides baseline data for further investigations and field trials.

INTRODUCTION

Rodents (Mammalia, Rodentia) are characterised by the possession of two continuously growing incisors in their upper and lower jaws. Constituting over 40 percent of mammalian species, the Order Rodentia remains the largest Order of mammals in terms of number of species with about 2,277 species of rodents worldwide (Wilson and Reeder, 2005). Their success is perceived to be due to their small sizes, short breeding cycle, and ability to gnaw and eat a wide variety of food (Lambert and Diagram Group, 2000). Rodents range in size from pygmy mice, *Mus minutoides* weighing 5g to capybaras, *Hydrochaeris hydrochaeris* that weighs more than 70 kg.

Rodents are of several uses to the ecosystem. Many rodents alter the structure of their environment by surface tunnelling, construction of leaf or stick nests, arranging pebbles around burrow entrances, or stripping the bark of trees. These activities provide living space or resource opportunities for other organisms and may affect plant composition in an area (Jones *et al*., 1997). Rodents reproduce rapidly, and therefore serve as a continuous food sources for many predators including man. They also function as agents of seed dispersal, serve as a source of fur and important model organisms in scientific research.

On the other hand, rodents can have negative effects on the ecosystem. Some species of rodents have been implicated in the extinctions of many species of birds, small mammals and invertebrates (Atkinson, 1996). They are also carriers of diseases such as lassa fever and bubonic plague (Centre for Diseases Control, 2009). In households around the world, they destroy papers and other materials and can also cause discomfort to humans through their bites. They are also known to cause considerable damage to agricultural produce (Chitty and Southern, 1954). Appiah and Attuquayefio, (2000) reported rodents to have caused up to 57% destruction of oil palm plantations in the Eastern Region of Ghana by gradually chewing the succulent apical buds of oil palm seedlings and killing them in the process.

As a result of these, human have long sort measures to keep the population of rodents down. Rodent control measures may include cultural, biological, mechanical and chemical means (Buckle and Smith, 1994). Cultural control of rodents includes practices that aim at preventing rodents from access to favourable environment while biological control involves the use of natural enemies of the rodent. Cultural control measures work very well in the control of rodents in household but can be problematic when applied to large farmlands surrounded by large tracts of bush (Chitty and Southern, 1954). On the other hand, biological control is useful when the rodent population is not high (Chitty, 1954). Physical destruction, use of rodent traps and glue boards constitute the mechanical control of rodents and this is most useful when the rodent population is not high. However mechanical methods often fail in the household if the rodent is trap shy (Clark, 1994). Chemical control of rodents involves the use of rodenticides and rodent repellents. Chitty and Southern (1954) showed that rodenticides are the most extensively used method in the control of both household and large infestations of rodents although the problems of development of resistance arise when the chemical is used constantly over a long period of time (Whisson, 1996).

Rodenticides are chemical substances used to kill rodents. Rodenticides come in different forms ranging from powdered, concentrates, mixed baits through small pellets. A rodenticide may be anticoagulants or non-anticoagulant (Whisson 1996). Anticoagulants rodenticides work by preventing blood clotting in rodents resulting in the rodents bleeding into their joints and muscles. Anticoagulants rodenticides often contain warfarin, coumateryl, difenacoum, brodifacoum, flocoumafen, bromadioline or pindone as their active ingredients (Whisson, 1996). The non-anticoagulant rodenticides target certain organs in the body and cause disruptions in the function of these organs resulting in the death of the rodents (Dipalma, 1981). For instance, bromethalin is a non- anticoagulant rodenticide that relaxes the muscles resulting in paralysis and then subsequently death. Other examples of non anticoagulant rodenticides include White Arsenic, Thallium Sulphate, Strychnine, Strychnine Sulphate, Calcium Cyanide and Zinc Phosphide (Dipalma, 1981).

All over the world, large sums of money are often spent on rodenticides in order to control rodent populations. In the presence of many reports of unapproved goods on the Ghanaian market, a number of rodenticides exist on which there is limited scientific data on their efficacy and use. There is therefore the need to scientifically examine the efficacy of rodenticides on the Ghanaian market to boost public confidence and reduce rip-offs.

MATERIALS AND METHODS

Choice of rodenticides

Personal interviews were conducted with hawkers and operators of agro chemical shops in the

Madina and Accra Central Markets both in the Greater Accra Region of Ghana. The interviews were conducted to identify the types of rodenticides available on the markets. After a number of random visits to the markets four different rodenticides were encountered. These were Baraki, Zinc Phosphide, Chinaman and Storm.

Baraki rodenticide is an anticoagulant that functions by causing internal bleeding in the rodent through the blockage of the production of essential clotting factors. The active ingredient is difethialone at a concentration of 0.0025% w/w (Clark, 1994). The bait comes in the form of unpolished rice grains and it was reported to mummify the body of the dead rodent and subsequently prevent bad odour (Agro. Evo, 2009). Storm has the active ingredient Flocoumafen at a concentration of 0.005% w/w and comes in small blue blocks. The *Zinc Phosphide* obtained was in a powdered form that was to be mixed with feed and then administered. When Zinc Phosphide comes into contact with dilute acids in the stomach, phosphine (PH_3) is released and this causes death in rodents (Whisson, 1996). The active ingredient in Chinaman is diphacinone at a concentration of 0.005% w/w. Diphacinone is a highly toxic substance that causes internal haemorrhage by inhibiting enzymes involved in blood clotting (Tintinalli *et al.,* 2004). Symptoms of diphacinone poisoning in rodents include laboured breathing, muscular weakness, excitability, congested blood flow to the lungs, and irregular heartbeats. Other signs of poisoning include spitting of blood, bloody urine or stools, and widespread bruising or bleeding into the joints (Thacker, 2001). Further information on each of these rodenticides is summarised in Table 1.

Laboratory work

Twenty (20) adult female white laboratory rats (*Rattus novigicus*) with an average weight of 277.5 ± 12.5g each were purchased from the Noguchi Memorial Institute of Medical Research (NMIMR) and transferred to a laboratory in the Animal Biology and Conservation Science Department, University of Ghana. Female rats were chosen for this work because they are known to be comparatively less sensitive to toxins than males (Peters and Boyd, 1967). The exclusive use of females therefore ensured uniformity in the results and enhances the reliability of the findings.

The white laboratory rats were put into individual rectangular mesh cages measuring 40cm x 20cm x 15cm where they were kept for four days to get them acclimatized to their environment. During this acclimatization period, they were supplied with water and the cereal based feed that was used to feed them in their former place of abode. On the fifth day, the rats were starved of food for 24 hours to ensure that they eat what would be subsequently presented to them.

Table 1: Parameters of the rodenticides used

Name of Rodenticide	Manufacturer	Characteristics	Manu. Date	Expiry Date	Batch No.	Wt of Bait Administered Per Rat (G)	Number of Rats Used
Baraki	Agro. Evo Environmental Health Ltd , United Kingdom	Concentrate	September 2009	September 2011	Not available	40	4
Zinc Phosphide	Not available but labelled to be made in China	Powdered product requiring mixing	Not available	Not available	Not available	40	4
Chinaman	Not available but labelled to be made in China	Concentrate	Not available	Not available	Not available	40	4
Storm	SOREX LTD, United Kingdom	Concentrate	October 2008	November 2010	6287J08	40	4

Forty grams (40g) of Baraki, Chinaman and Storm rodenticides were each presented to individuals of four rats. Using the manufacturer's instruction, two packs of the dark gray powdered Zinc Phosphide rodenticide was mixed with 38g of corn flour and groundnut paste to form a bolus weighing 40g. After 24 hours of exposure to the rodenticides, the leftover bait was collected and weighed. The amount of bait consumed was determined as the difference between the 40gm and the leftover rodenticide. Normal poison-free feed made of cereals obtained from the Noguchi Memorial Institute of Medical Research was given to the rats after the removal of the rodenticide. Four rats, in individual cages, were used for a control experiment. They were given the cereal based feed acquired from the Noguchi Memorial Institute of Medical Research through out the experiment. All rats were given water through out the experiment. The rats were monitored for a period of seven days after the removal of the rodenticide. Data was analysed using PractiStat Statistical Program (Ashcroft and Pereira, 2003).

RESULTS

Among the rodenticides, Storm recorded the highest intake (20.6±1g) followed by Baraki (17.8 ± 5.5g), Chinaman (5.4 ± 0.3) and Zinc Phosphide (3.2 ± 1.7g) [Table 2]. Statistical analysis showed that acceptability of Storm and Baraki were significantly higher than Chinaman and Zinc Phosphide (Table 2) (ANOVA with post hoc Fisher's LSD test, $p < 0.05$). Table 2 further revealed the product acceptability of Storm and Baraki was also statistically similar to the acceptance of the control feed but that of Chinaman and Zinc Phosphide were significantly lower.

Deaths occurred in the rats that consumed Baraki, Storm and Zinc Phosphide but not with the consumption of Chinaman rodenticide (Table 2). Consumption of the Zinc Phosphide rodenticide resulted in the death of all four rats on the first day, contrary to the consumption of Baraki and Storm that recorded 4.0±1 and 3.8±1 days respectively as mean times of death. The average time of death after the consumption of Zinc Phosphide was significantly lower than that of Baraki and Storm (ANOVA with post hoc Fisher's LSD test, $p < 0.05$). No death occurred in the rats that were used as control.

DISCUSSION

According to the laws governing the sale of chemical substances in Ghana, the instruction or labelling on all rodenticides to be sold on the Ghanaian market should be in a language that is officially spoken in Ghana before they can be certified. Of the four rodenticides found on the market, Zinc Phosphide did not meet this criterion – the labelling was in French. Although the list of approved rodenticides on the market was not released for this work on ethical grounds, it was certain that the Zinc Phosphide, though efficacious, was not approved for the Ghanaian market.

Table 2: Bait intake and time of death in rats fed with rodenticides

Rodenticide	Mean Bait intake(g) ± SE*	Mean time of death (days) ± SE
Storm	$20.6±1.3^a$	$4.0±1^a$
Baraki	$17.8±5.5^a$	$3.8±1^a$
Chinaman	$5.4±0.3^b$	-
Zinc Phosphide	$3.2±1.7^b$	1.0^b
Control	$18.7 ± 6.2^a$	-
LSD (p < 0.05)	5.44	0.34

**Column Means followed by different letter(s) are significantly different at P < 0.05.*

The fact that there was no significance difference among the amount of Baraki, Storm and the control feed ingested implies that the acceptability of these two rodenticides was not affected by their rodenticidal properties. Acceptability of Chinaman and Zinc Phosphide was however affected since the quantities consumed were significantly lower than the control feed. Zinc Phosphide is a fast acting rodenticide and it appeared to have caused severe sickness and discomfort in the rats shortly after it was ingested.

The observation of deaths in all the rats that consumed Storm and Baraki is an indication of the potency of difethialone and flocoumafen as rodenticides. Saxena *et al* (1992) reported 100% mortality in *Rattus rattus, Mus musculus, Funambulus pennanti* and *Meriones hurrianae* that were exposed to difethialone. Similarly, field trial of flocoumafen on rats in the United Kingdom resulted in eradications or reductions between 87% and 96% in rat populations (Lund, 1988). Though Zinc Phosphide was perceived to be uncertified for the Ghanaian market, all the rats that were exposed to it died on the first day of consumption. Although equally effective against the control of rats, the mean time of death was thus significantly shorter than that observed for Baraki and Storm. According to WHO (1976), rats and mice that ingest lethal amounts of Zinc Phosphide usually succumb immediately with terminal symptoms of convulsions, paralysis, coma, and death from asphyxia. Buckle and Smith (1994) reported that although Zinc Phosphide remains toxic up to several days in the gut of a dead rodent secondary poisoning only occurs if animals eat enough of the gut content of rodents that are freshly killed with Zinc Phosphide.

The only rodenticide that did not produce any lethal effect after exposure to the rats was the Chinaman rodenticide. All four rats exposed to it were alive on the seventh day after the exposure. It could be that the Chinaman rodenticide did not actually contain the active ingredient diphacinone or that the acceptability was so low that the rats failed to consume quantities that would be lethal to them.

According to Chitty (1954) a good rodenticide should be acceptable to rodents at lethal concentrations and must have a delayed effect since rodents feed by eating small quantities at a time and wait for sometime before continuing if they do not get sick. This study suggested that Baraki and Storm meet the requirements of acceptability and delayed effects. The results further suggested that although Zinc Phosphide did not exhibit delayed effects, the amount needed to produce lethal effects in white laboratory rats was small and this can be consumed after a single encounter.

The major deficiency associated with this work is the sample size of four rats that was used per test which can be considered to be small. This small sample size was motivated by difficulties associated with the availability of the rats for the study. Nevertheless the study provides a useful baseline data for further investigations and field trial.

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